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U.S.
NATIONAL BUREAU OF STANDARDS

Technical News Bulletin

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Technical News Bulletin
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Cover: Playing with matches or lighters has led to many a tragic fire. For further details, see page 215.

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

Center for Computer Sciences and Technology

Center for Radiation Research

Center for Building Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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NEW TECHNIQUES FOR HIGH VOLTAGE MEASUREMENTS

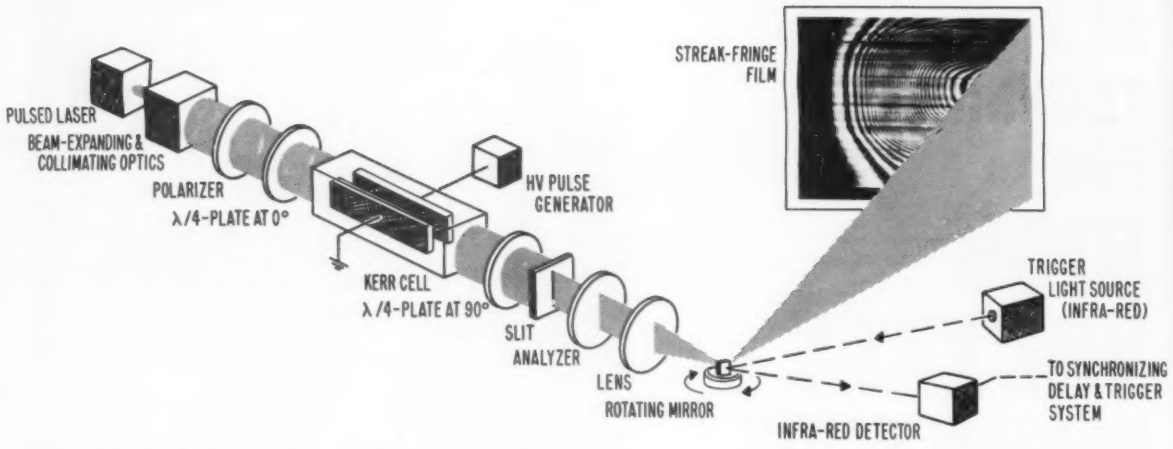
W. A. Bagley aligns the system used for HV pulse measurements. When sufficient voltage is applied to the Kerr cell (center) laser light is transmitted through the cell to the high-speed camera (lower right). Analysis of the resulting fringe patterns gives a measure of the voltage.

New techniques for measuring pulsed high voltages and for probeless electro-optical studies of transient electrical stress have been developed[1] at NBS. These methods, based on optical fringe-pattern measurements similar to those employed in earlier NBS work under high direct voltage conditions,[2] have been used for measuring microsecond pulses in the kilovolt range. They also show promise of application in the megavolt range where electrical interference and noise make accurate measurements extremely difficult.

Thus far, the techniques, developed by Esther C. Cassidy of the Electricity Division in a joint effort with Stanley R. Booker of the Sandia Corp. of Albuquerque, N.Mex., have been useful for HV calibration studies.[3] Their use for dynamic electrical stress analysis and for studies of the behavior of liquid dielectrics is anticipated. In addition, their insensitivity to electrical interference suggests that they may be uniquely suited for voltage measurements during testing of electrical equipment under simulated lightning impulse or nuclear explosion conditions.

The system produces optical recordings of time-varying fringe patterns produced by electrical stress imposed by the applied HV pulse. The fringes, which result from electro-optic modulation of the light beam intensity, transmit the measurement information to ground. Only the Kerr cell modulator, which is a passive device, is connected to the HV level. And, unlike other methods, the new NBS technique eliminates the need for sensitive electrical or electronic detecting devices and recording equipment.

The system consists basically of a calibrated Kerr cell, an expanded-beam pulsed laser, and high-speed photographic equipment. The Kerr cell is composed of two electrodes immersed in a dielectric liquid, which becomes birefringent in the presence of an electric field.



Drawing of the system for measuring transient high-voltage pulses from fringe patterns.

Although other liquids with relatively high Kerr constants are suitable, nitrobenzene has been used in most of the NBS work.

In operation, the laser illuminates the Kerr-cell interior, through and along the length of the electrodes. Crossed polarizers are positioned in the light path at both ends of the cell so that initially no light is transmitted. When the voltage to be measured is applied across the electrodes, the imposed electric field produces birefringence in the cell liquid (the Kerr Effect). This alters the state of polarization of the light, which is then transmitted through the cell.

When a voltage pulse of sufficient magnitude is applied, space variations in the transmitted light produce a transient electro-optical fringe pattern made up of alternate bright and dark bands. The number and positions of the bands change rapidly in response to the changing pulse magnitude. If "frozen" at any instant in time, the brightest (or darkest) points of each band delineate "equifield" lines of known relative electric field strength. In effect, they "map" the intensity and distribution of the transient field between and around the Kerr cell electrodes.

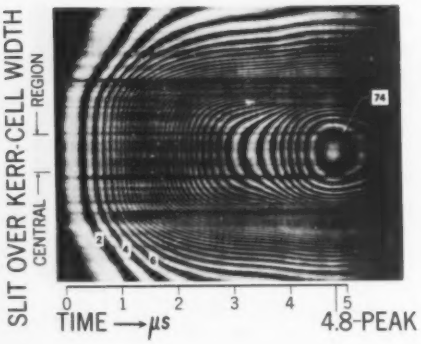
The fringes are numbered, $n = 1, 2, 3 \ldots$; odd numbers are assigned to the bright fringes and even integers to the dark fringes. Voltage or field strength are easily approximated within a few percent (comparable with typical oscilloscope accuracy) from these values. Greater accuracy is obtained with measurement of interfringe transmission intensity.

For electrical stress studies the operation under short pulse conditions eliminates space-charge distortions of the field, often a problem in the earlier steady-state high-voltage measurements. The fringe-pattern photographs therefore enable experimental visualization of the "ideal" field distribution produced with a cell structure of given design.

An argon-ion laser, with flash duration of 6 μs and peak power of 5 watts, was employed in the NBS work. Electronic delay and trigger generator systems were used for synchronizing the high-speed photographic exposures with flashing of the laser, with firing of the pulse generator applying high voltage to the Kerr cell, and with triggering of a dual-beam oscilloscope which recorded pulse-divider measurements of the pulse. The latter enable comparative evaluations of fringe-pattern measurements with conventional electrical measurements.

An image-converter camera with exposure time of 1, 0.3, or 0.1 μs, a laboratory-constructed streak camera with maximum speed of 1,800 rps, or a commercially available combination streak-framing camera with 5,000 rps maximum is used to record the high-speed fringe

Streak camera record showing continuous fringe-pattern measurement of the first half of a pulse peaking at 86.4 kV.

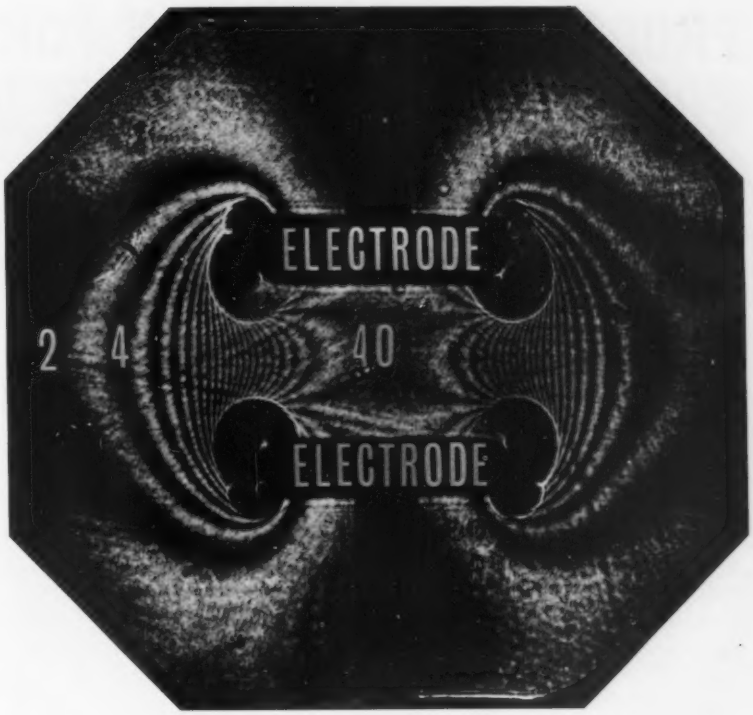


patterns. The image converter exposure allows a high-speed fringe pattern to be "frozen" at a selected time during the HV pulse. The streak cameras record continuous time-resolved photographs. In this case, the fringes are numbered in sequence as a function of time. The framing camera, equipped with a seven-frame module, yields high-speed exposures taken in sequence at different times during application of the HV pulse. Each frame yields a photographically "frozen" record of the transient fringe pattern as it extends over the entire area (end-view cross section) between and surrounding the Kerr cell electrodes, enabling measurements of time-variations in the voltage and studies of time and space variations in the two-dimensional electric field distribution

[1] Cassidy, E. C., Pulsed laser Kerr system polarimeter for electro-optical fringe-pattern measurement of transient electrical parameters, Rev. Sci. Instr., **43**, 6, 886-893 (1972).

[2] Cassidy, E. C., and Cones, H. N., A Kerr electro-optical technique for observation and analysis of high-intensity electric fields, J. Res. Nat. Bur. Stand. (U.S.), **73C**, 5-13 (1969).

[3] Cassidy, E. C., Cones, H. N., and Booker, S. R., Development and evaluation of electro-optical high-voltage pulse measurement technique, IEEE Trans. **IM-19**, 395-402 (1970).



Fringe pattern showing the electric field distribution produced by a 65,000-volt pulse over a cross section (end view) area between and around the Kerr cell electrodes. In a new technique developed by NBS, instantaneous voltage can be calculated from such fringe patterns.

Photometric and Radiometric Intercomparisons

A program under development by the Optical Radiation Section will permit calibration laboratories to demonstrate their measurement capabilities in luminous intensity and spectral irradiance through lamp intercomparisons with NBS.

Initially, participation will be limited to public issuance calibration laboratories and, because of the limited NBS facilities available, will be on a first-come, first-serve basis. The intercomparison of luminous intensity measurements will begin early in November 1972, and will cost the participants between $1,000 and $2,000. Approximately 1-man week of work will be involved in the participating laboratories.

The Optical Radiation Section has recently re-realized its scale of spectral irradiance. In order to give interested laboratories a chance to obtain and convert to the new scale, the spectral irradiance intercomparison will not begin until January 1973. It is expected that participation in this intercomparison will cost roughly the same as the luminous intensity intercomparison.

Laboratories interested in participating in either of these intercomparisons may obtain further details from:

Donald McSparron
NBS, Optical Radiation Section,
Metrology Building, Room B312
Washington, D.C. 20234
(310) 921-2113

PROPOSED LEGISLATION FOR COMPUTER RESEARCH AND DEVELOPMENT

Computer-based electronic point-of-sale terminals increase productivity in retail merchandising.

On May 16, 1972, Dr. Lawrence M. Kushner, Acting Director, NBS, and Dr. Ruth M. Davis, Director of the NBS Center for Computer Sciences and Technology, testified before the Government Activities Subcommittee of the House Committee on Government Operations.* The Subcommittee was holding hearings on H.R. 13200, a bill to improve Federal policymaking regarding computers.

H.R. 13200, introduced on February 17, 1972, by Congressman Jack Brooks, Chairman of the Government Activities Subcommittee, has three principal provisions:

1. Provide limited funding, not to exceed $3.5 million in any fiscal year, to the Computer Board of the National Academy of Sciences for costs incurred in conducting studies or evaluations and performing other services at the request or on behalf of Federal agencies.

2. Authorize Federal expenditures of $100 million for basic research in computer technology to be administered by the Director of the National Bureau of Standards.

3. Amend P.L. 89-306 to allow the Administrator of General Services to enter into contracts for periods of up to 5 years in the leasing of computers and related services needed by the Federal Government.

In introducing the bill, Congressman Brooks observed that "broad segments of our economy and most of the Nation's defense systems rely upon computers, and they offer vast potential in the solution of many of the extremely difficult social problems confronting the Nation." He went on to observe that "if the United States loses its leadership in computer technology—if we become a second-rate computer power—we will become at the same time a second-rate Nation, both economically and militarily."

In his testimony, Dr. Kushner said "we view the intent of Section 2 of the bill as a vote of confidence in the direction of the present NBS program in computer sciences and technology. Of equal importance is the recognition the bill affords to the need for the Federal Government to encourage private research and development directed towards accelerating the pace at which computer science and technology ad-

*Others testifying on H.R. 13200 included Dr. Philip Handler, President of the National Academy of Sciences, Dr. Anthony Oettinger, Chairman of the Academy's Computer Science and Engineering Board, Mr. Milton S. Meeker, Commissioner of GSA's Federal Supply Service, Dr. Bruce Gilchrist, Executive Director of the American Federation of Information Processing Societies, and Mr. Vico Henriques, Business Equipment Manufacturers Association.

vances to improve the lot of each of us in today's world."

Dr. Kushner continued "we are highly conscious in the computer world of the difficulties of harnessing novel technologies and radically new ideas so that they will have a positive impact on society and our economy. Fortunately, a strong emphasis is now being placed by the President on research to find mechanisms to improve the incentives for, and decrease the barriers to, innovation in the private sector. The Department of Commerce to which the President, on March 16, 1972, assigned the responsibility of being a focal point within the Executive Branch for policies concerning industrial research and development, is initiating programs to achieve that goal." He observed that there is already a high incidence of computer problems resulting from a lack of technology to support adequate marketplace mechanisms for computer products and services; he said, "it is almost unbelievable that the customers of the eighth largest industry in the United States have received so little directed attention from the Federal Government; our program at NBS is directed towards overcoming these present deficiencies."

Dr. Kushner recommended against Section 2 of H.R. 13200, however, noting that "adequate authority and unrestricted funding authorization already exists for the Department of Commerce to carry out the tasks described in Section 2."

Dr. Davis introduced her testimony by stating that "we are convinced of the seriousness of the problems besetting both the consumers of computer products and services and the suppliers of these products and services." She underscored Dr. Kushner's statement of the need for the Federal Government to encourage private research and development directed towards accelerating the pace at which computer science and technology advances to improve the lot of each person in today's world. Dr. Davis went on to make the following major points regarding the need for computer technology research and development:

THE CHANGING WORLD OF COMPUTER APPLICATIONS, SCIENCE, AND TECHNOLOGY

In the early 1950's almost all computer services were federally sponsored. Likewise, almost all computer R&D was federally sponsored. Federally sponsored computer R&D was specialized by computer application and agency mission. Happily, in those days, advances in computer science made to overtly serve specific agency applications were, because of the primitive nature of computer science, also advances to the science in general and of direct benefit to all computer customers. The Federal Government amassed a well-known and noteworthy record during those days in the support of computer science and technology.

This scenario is no longer valid. The computer world of the 1950's was more simplistic than that of the 1970's. The computer customers in the 1950's were principally Federal customers. In particular, the military buyer was dominant. He had the real urgency of national security as his goal: The computer user was asked to adapt to the computer and not the computer to the customer. Demand was greater than the supply and the customer was totally forgiving. Standards of quality and of performance were secondary to the delivery of hardware. Documentation of products—which we now refer to as consumer information—was considered a frill, slowing down advances in technology and delivery of services.

These certainly are characteristics of any new, complex much-in-demand technology. The positive results are apparent—the computer industry is the eighth largest in the country. The superlatives describing the role of computers tell us that the arrival of computers was equivalent in importance to the industrial revolution and that computers are essential to our survival as a post-industrial nation. At the same time, we must also recognize the residue of problems left behind in the wake of this rapid advance of technology and the spread of computers in our country. These problems are those of quality control, performance measurements, documentation, and standards. They are the special province of the Department of Commerce under P.L. 89-306.

Today, the Federal ownership of computers has declined from close to 100 percent of the national computer inventory of the early 1950's to about 7 percent of the national inventory of 88,000 computers. State and local governments, the financial community, some service areas and segments of industry all own more computers than the Federal Government.

As we might expect from this, many of the computer services performed in the public interest are not provided directly by the Federal Government. However, the Federal Government bears much of the responsibility for protecting the public and the consumer who are the recipients of these services.

THE RECIPIENTS OF COMPUTER SERVICES

It is critically important for us to recognize the distinction between recipients of computer services and customers for computer services. The recipient of computer services differs from the customer in that the recipient has generally not made a conscious choice to be served by computers. Recipients of computer services are not willing to adapt to the computer as were the early users of computers, nor should they be asked to. Recipients of computer

services are not forgiving of the mistakes made by the computer or by its managing organization. They are demanding both information on and assurance of quality and performance. With 88,000 computers in our national inventory, we have one computer for every 2,300 citizens or one computer for every 730 families. There is thus a large constituency of concerned citizens hoping for more humane applications of computer technology. Within the Federal Government, the Department of Commerce, and NBS in particular, has the responsibility for meeting these needs.

PROBLEMS IN COMPUTER UTILIZATION

The principal problems in computer utilization which have accumulated over the last 25 years can be called public interest computer problems. They are resolvable only through directed efforts to insure that the accuracy of data entered into computer systems is not degraded and to assure the correctness of the software which manipulates, combines, and processes these data. They require manageable means for controlling access to computer systems so as to protect the privacy of the data in those systems. They require more productive means of producing software coupled with standards of quality of that software. Software management is that area of technology which encompasses efforts to overcome these types of problems.

Some of the public-interest computer problems causing the most anxiety and aggravation are those involving the coupling of computers and people so as to enhance the capabilities of both. These problems are manifest in the stresses of workers trying to adapt to increased automation both in the manufacturing and in the services industry. They are apparent in the education community as it attempts to use computers. They are evident in the deliberations of Congress as it tries to find answers to the highly emotional problems surrounding the identification of individuals and data about individuals in computer data banks.

HISTORY OF FEDERALLY SPONSORED COMPUTER R&D

Recently, we initiated our first effort, in line with our responsibilities under P.L. 89-306, to make a detailed analysis of Federal R&D. We used the most comprehensive accessible source of such information; namely, the Science Information Exchange (SIE). Even so, the project data available from the SIE does not present a total picture of Federal R&D projects. Caution, therefore, must be exercised in interpreting or drawing too rigid conclusions from it.

Some of the highlights of these analyses are that the DOD sponsored some 58 percent of the total Federal R&D projects, NSF an additional 18 percent for a combined total of 76 percent. The remaining 24 percent were sponsored by 11 Federal agencies. Such a concentration of the power of R&D projects gives us an indication of the orientation of federally sponsored computer R&D.

Twenty-one percent of the projects were concerned with hardware design, 40 percent were concerned with the needs of special interest communities such as natural sciences, engineering, social and behavioral sciences, humanities and real-time systems, 14 percent were in the long-range pay-off areas of metatheory while only 9 percent were oriented to the highly agonizing software problems identified by most customers as their major concern.

We believe that the need for the NBS program aimed at resolving the problems associated with computer utilization in support of public services and the marketplace needs of the public customer is apparent. Such public interest R&D can be a highly potent agent for public policy. One of its aims would be to achieve computer performance and computer coupling with people that would minimize those deleterious changes in human behavior and human rights that might be forced upon us by the uncontrolled use of computers. As a correlative to this goal, computers would now be able to give to individuals in society more control over their individual environment than they have ever been able to exercise before.

In a real sense, the NBS computer R&D program is application-independent or mission-independent. For example, the means for production of quality software is independent of the application of that software. Similarly, the solution to the problems of controlled accessibility or privacy of data banks is independent of whether the data are medical records or credit records: It is also independent of whether the computer data bank belongs to the FBI or to the Census Bureau. In the same vein, we know that computer network problems afflict in an identical way university users, air-traffic controllers, the General Services Administration, and the intelligence community.

We feel it extremely important to focus our resources at NBS on these mission-independent problems which have become so aggravating to customers and recipients of public computer services.

COMPUTER TECHNOLOGY NOT DESIGNED FOR TRANSFER

We would be deluding ourselves if we implied that the transfer of computer technology from its initial intended purpose to a second purpose were easy. . . . A common problem encountered in attempts to transfer computer technology arises from the lack of sufficient documentation on the initial technological product to determine its applica-

bility to a second function. The expense of redetermining and bounding the range of applicability of a technological product without the guidance of its developers often precludes its practical transferability.

Indeed, it is painfully clear that the same objectives of quality control, standards of documentation, performance measurement, and product/services accuracy are as necessary for computer technology transfer as for acceptable public service applications of computers.

A computer technology whose products are not subjected to customer criticism and customer appraisal in a rational marketplace is a kept technology. And computer technology today is a kept technology. Both its supporting industry and its Federal and public customers will suffer until we have a Federal computer program which puts them on their respective economic feet.

COMPUTER STANDARDS

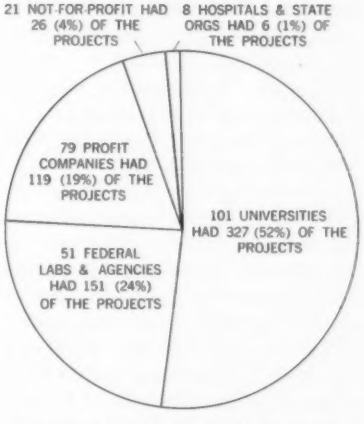
One of the important areas of computer technology is that of the widespread and complex set of tasks which will result in standards

The Computer Industry: Subindustry Member Population and Sales Volume

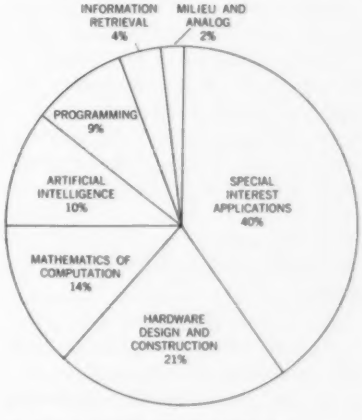
Major Subindustries	Number of Member Companies	1970 Sales Volume ($ Millions)
Equipment		
Mainframe (CPU) Manufacturing	8	4100
Peripherals Manufacturing	400–450	1620
Mini-Computer Manufacturing	50–75	250
Equipment Leasing Services (Third Party Services and OEM)	175	600
Software		
Independent Software Producers	1100	340
Mainframe, Users, Universities	25	240
Computer Services		
Regular Service Bureaus	800	600
Time-Sharing	225–235	490
Libraries	12	—
Facilities Management Services (Computer Resource Management-CRM)	12	180
Computer Network Services	5	N/A
Major Support Subindustries		
Electronics Components	65	600
Computer Technology (Research)	10–15	—
Education and Training Services	750	170
Media Suppliers	84	1170
Minor Subindustries		
Automated Reading Equipment Manufacturing	40	60
Process Control Device Manufacturing	1100	180
Soft Automation Manufacturing	5	40–50

Source: Individual Company and Trade Journal Material Available at the NBS.

In FY 1971, the Federal Government sponsored a total of 629 projects in computer sciences and technology. This chart shows the number of projects and the percentage of the total sponsored by various agencies.


21 NOT-FOR-PROFIT HAD 26 (4%) OF THE PROJECTS
8 HOSPITALS & STATE ORGS HAD 6 (1%) OF THE PROJECTS
79 PROFIT COMPANIES HAD 119 (19%) OF THE PROJECTS
101 UNIVERSITIES HAD 327 (52%) OF THE PROJECTS
51 FEDERAL LABS & AGENCIES HAD 151 (24%) OF THE PROJECTS

This chart shows the distribution of federally sponsored R&D amongst various types of performing organizations. The number of each type of organization is shown, together with the number and percentage of projects.



Technical categorization of federally sponsored computer R&D.

governing quality control, performance measurement and consumer documentation for computer services, applications, and systems.

The Federal Government may be proud of its progress in developing standards under its Brooks Bill charter. Thus far, 18 FIPS standards have been published and some 14 more are planned for fiscal year 1973.

The development of computer standards designed in the public interest and their supporting technologies form a significant portion of our NBS program in computer sciences and technology. We consider it one of our most important responsibilities.

COMPUTER PROBLEMS

In general, the determination of computer problems has been a haphazard process. We have recently enlarged the traditional sources of computer problems used to formulate R&D programs to include those reported during Congressional hearings, those reported to consumer protection groups around the country, those cited in antitrust suits filed within the computer industry, and those implicit from reports of unduly expensive system costs.

The crippling problems are lining up in the software rather than in the hardware field. In particular, they fall under what we call the application-independent problem category and cluster in the areas we have described earlier. These are software problems which are common to many applications. A grouping of crucial computer problem areas follows:

1. Poor quality software.
2. Lack of controlled accessibility to computer data banks.
3. Lack of adequate documentation on applications software.
4. Unsatisfactory performance of computing systems.
5. Difficulties in producing applications software.
6. Lack of marketplace standards and specifications.

The most productive approach to the solution of these problems lies in a focused, coordinated, adequately-funded effort rather than through multiple, disparate efforts each marginally funded by individual agencies. The wastage of scarce industry resources attempting to respond to a barrage of separately originated requests for scientific services is unjustifiably counterproductive.

THE COMPUTER INDUSTRY AND ITS PRODUCTIVE UTILIZATION OF FEDERAL R&D FUNDING

We have been concerned with the extent of national capabilities available in computer-oriented competencies on which to productively expend Federal funding. We have talked with over 80 industry representatives regarding H.R. 13200 since its introduction on February 17, 1972.

We are convinced, as an outcome of our analyses, that the computer industry has changed so rapidly that many people dealing with it have an outdated impression of it. The thought that the industry can be identified as consisting of eight major mainframe manufacturers can charitably be called a myopic mythology. The computer industry today can best be described not as a single entity but as a set of interrelated subindustries.

Admittedly, a decision on what to include in the set is to some degree arbitrary. However, we have attempted to identify as computer subindustries those industries which derive their primary source of income from the production and use of the computer or in which the computer is fundamental to the existence of their product or service. Using this approach, 17 subindustries with some 4,900 member companies have been identified. This structure is shown on page 213.

The 1970-71 documented Federal R&D funding went to less than 2 percent of these 4,900 companies. The problems we must tackle if we are to best serve the public interest will impact directly on the operations of those 1,100 (including eight mainframe manufacturers) companies having software products and services as a major source of income. The principal technical capability which we must use our funding to procure to work with us on our critical computer problems will probably also come from 1,100 of these 4,900 companies. The overwhelming majority of these companies are too young and struggling to have the internal resources available for sponsoring any development activities. And yet, they surely possess excellent technical innovative capabilities. They must become partners in our "computers in the public interest" program.

We are quite cognizant of the impact that Federal funds can have on the structure as well as the direction and rate of growth of the computer industry. We also believe that the Federal Government and the industry need to improve their understanding of themselves in order to gain maximum benefit from Federal funds expended to improve the utilization of computers in public services.

CONCLUDING STATEMENTS

Imaginative use of computers may well hold the key to necessary improved productivity in our domestic economy. Already, our skill in computer technology is one of the most valuable economic and technical assets we possess as a Nation. The timing is right, the needs are apparent and the Federal Government is ready to employ computers to aid our economy and to assist in improving the lot of each of us individually. We intend that the National Bureau of Standards play a leadership role in this effort.

Study Indicates

NEED FOR SAFER MATCHES AND LIGHTERS

Many lives could be spared if matches and lighters were redesigned to make them difficult or impossible for children to ignite.

That's the conclusion of studies by NBS scientists involved in fire research.

People have long recognized the danger of children playing with matches. Now NBS has put this danger on a quantitative basis.

The NBS study has revealed that 28 percent of accidental garment fires result from match or lighter ignition. Especially tragic is the fact that children—particularly those under 10 years of age—are most often the victims of these fires.*

The study showed that together matches and lighters accounted for 24 percent of all fabric fires, which includes three broad categories of materials—garments, bedding, and other furnishings. Matches were the ignition source of these fires five times more often than lighters.

In case studies involving match ignition, 44 percent of the victims were children under 10 years of age, while children under 6 years old accounted for 29 percent. Practically all of these cases involved playing with, rather than using, the matches or lighters. The other 56 percent of the cases were spread over the remaining age groups, with accidents tending to occur more frequently with increasing age over 36 years. Among older victims, the accidents tended to occur while people were using matches or lighters as they were meant to be used. In less than 5 percent of the cases, the victims had been involved with alcohol or narcotics.

The study was carried out under responsibilities assigned NBS under the Flammable Fabrics Act, as revised and amended in 1967. That Act calls for the Secretary of Health, Education, and Welfare, in cooperation with the Secretary of Commerce, to conduct a continuing study and investigation of deaths, injuries, and economic losses resulting from accidental burning of fabric products. Fire accident cases involving fabric products are investigated by Food and Drug Administration inspectors and others. Reports on the cases, together with remains of the fabric products involved, are sent to the NBS Office of Flammable Fabrics for analysis and testing. The Flammable Fabrics Office then processes the reports and fabric remains through its Flammable Fabric Accident Case and Testing System (FFACTS).

Processing at NBS includes reviewing and screening of case reports, laboratory testing and characterization of the fabric product, data encoding, formatting, editing, and entry into a computer file. As many as 200 data elements can be coded for each fire accident case. Information on the time and location of the accident, personal and socioeconomic facts about the victims, extent of injuries and losses, the sequence of events leading to the accident, the nature of the involvement of the fabric product, the fabric construction and fiber content, and the results of flammability test are analyzed in the program.

Studies of the data show how frequently different fabric products are involved in injurious fires and provide insight into trends and significant interrelationships between fabrics and fire sources. The information is used to develop priorities for national mandatory standards for the flammability of fabric products; to provide the basis for the development of realistic tests to discriminate between highly hazardous products and those of lower potential hazard; and to help understand other aspects of the flammable fabric problem. The prime objective is to identify and provide assistance in ranking the various ways of reducing the burden of deaths, injuries, and economic losses sustained from accidental burning of fabric products.

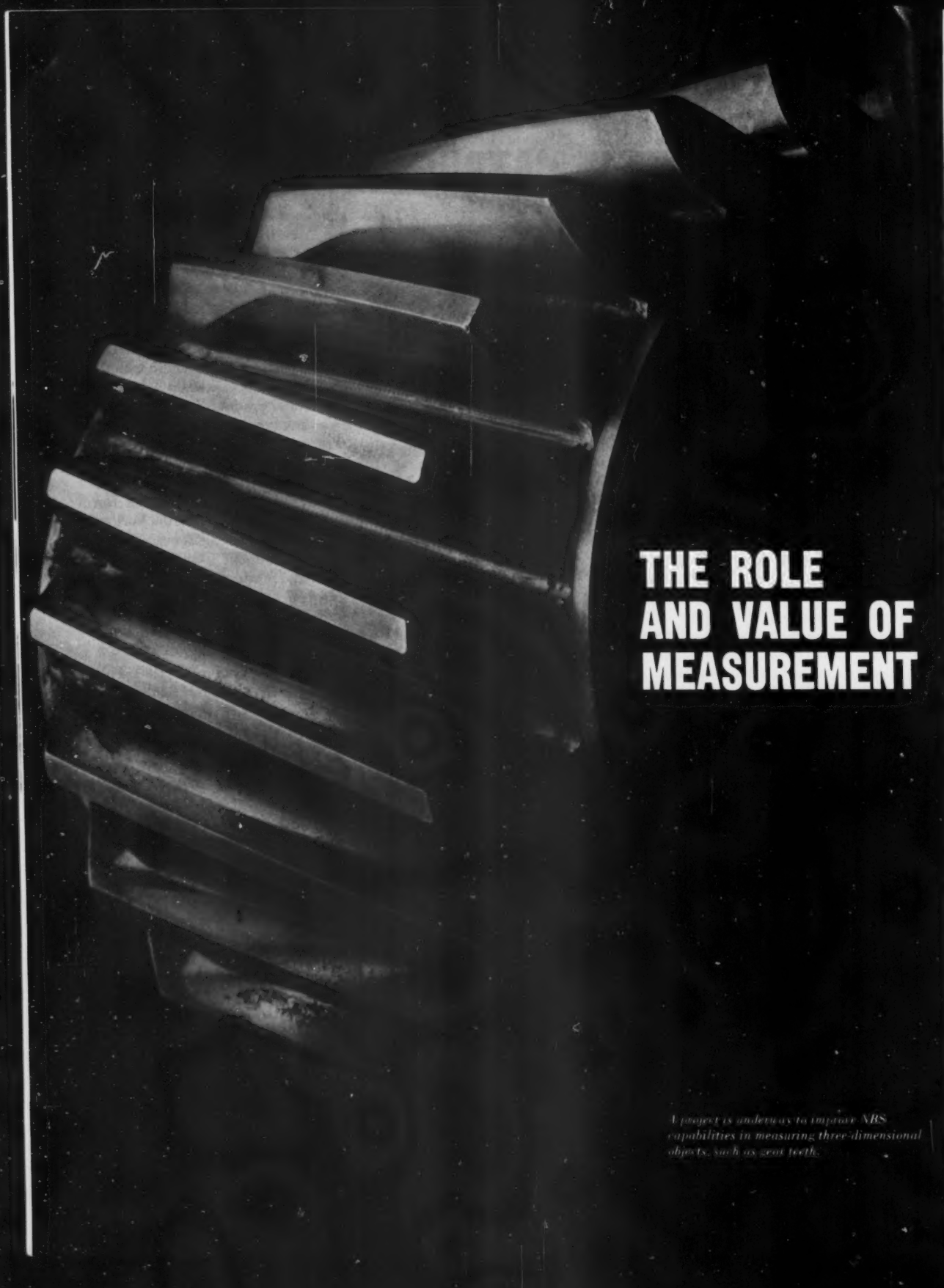
Considerable progress is being made in promulgating standards for flammable fabrics.

But the ignition-source problem has only recently been tackled. The problem is especially difficult when it involves fabrics not covered by standards and for fabrics that have lost their fire retardancy due to washing.

The Bureau's fire experts, based on their studies, recommend that matches be packaged in such a way as to limit a child's access to them and that design of matches and lighters be changed to make it virtually impossible for a child to ignite them.

A contract has been negotiated with the Trident Engineering Associates of Annapolis, Md., to study the chain of events leading to garment fires in which matches or lighters were the ignition sources and to recommend design changes in these items to reduce the hazards they present. Prototype safer matches and designs of prototype safer lighters are expected from this study.

*The data on which this article is based are maintained by the NBS Office of Fire Programs under the general supervision of Jim Slater, A55 Technology Building, National Bureau of Standards, Washington, D.C. 20234 (301) 921-3246.



THE ROLE AND VALUE OF MEASUREMENT

A project is underway to improve NBS capabilities in measuring three-dimensional objects, such as gear teeth.

Excerpts from a talk presented by Dr. Lawrence M. Kushner, Acting Director of NBS, at the Joint Measurement Conference held June 21, 1972, at the NBS Boulder, Colo. Laboratories, under the sponsorship of ASQC, IEEE, ISA, NBS, NCSL, and PMA.

We live in a dimensioned world. Knowledge is projected into numbers, and precise and reliable numbers constitute the firm foundation of scientific and technological structures. The more advanced a country becomes technologically, the more sophisticated is the system of measurement it requires.

To meet the measurement needs of our society, the most technologically advanced in the world, this Nation has evolved a measurement system which meets its own internal requirements and is in many ways coordinated with the measurement systems of other developed countries. This measurement system provides a quantitative basis for the interchange of goods and services in commerce, for the compatibility and interchangeability of machine parts and devices in industry, and for the consistency of scientific and technical information.

As standards laboratories, we have tended to focus our attention on the means by which the basic measurement units are realized, maintained, refined, and embodied in standards of ever-increasing sophistication. This is both a necessary and a challenging enterprise. New technologies demand increased measurement capability. Conversely, important gains in measurement capability make possible new approaches and better understanding of the factors affecting the application of physical theory.

Through a wide variety of instrumentation, in conjunction with standards, we acquire or establish pertinent numbers. When this instrument network is tied to a single, universal, self-consistent system of units, one can achieve the desired exchangeability of components and information between different places and at different times.

SPECIFIC MEASUREMENT NEEDS

Today, the Bureau is redirecting its attention to a growing number of measurement problems. For example, although our ability to measure length in one direction is adequate, our ability to measure complex shapes—multidimensional metrology—is lagging significantly behind the needs of some segments of industry. It is possible today to manufacture objects in complex shapes to precisions which exceed our ability to check the dimensions of the completed object. This is clearly an intolerable situation if quality control is to have any significance. Two-dimensional grids, used by mapmakers working from aerial photographs and by manufacturers of electronic microcircuits, cannot be calibrated to the extent that their users find necessary.

Navigational requirements, collision-avoidance systems for high-speed aircraft, and the need to use available electromagnetic spectrum space in the most efficient manner are creating demands for improvements in both our frequency standards and the means by which standard frequency signals are made available. In response, NBS has recently devised a technique for disseminating time signals and for clock synchronization using commercial TV along with satellite transmissions.

The techniques for measuring the output of conventional light bulbs are not satisfactory for determining the output of the new types of lighting devices, such as fluorescent, mercury vapor, or other lamps, now on the market.

The ubiquitous laser presents its own set of measurement problems as well as metrological opportunities. First, there is the problem of measuring power in order to assure safe use in a broad spectrum of applications. On the other hand, the very existence of the laser has opened a number of opportunities for improvements in metrological practices that would have been hopelessly beyond our capabilities only a few years ago.

In recent years Congress has assigned many new responsibilities to NBS.

Measurements in materials technology also afford stimulating and challenging problems. The characterization of materials to establish their suitability for application in biological or physiological systems is a particularly exciting area. Investigations at NBS of failures of materials, structures, and transportation equipment highlight inadequacies in the ability to characterize the properties of metals and other structural materials to assure their safe application.

The measurement of the performance of automatic data processing systems presents a major problem to the Federal Government, which now has an inventory of over 5,000 computer systems and spends over $2 billion a year in their operation. Yet it has little basis for objective judgment on the relative merits of systems offered by competing manufacturers. This results in the purchase of much more performance than is needed. Obviously, this is not the answer.

UNITS AND THEIR DISSEMINATION

The starting point for a system of physical measurement is, of course, the basic physics on which the units and their interrelation-

ships depend. The sophistication with which the units of the system are established has increased gradually so that we have nearly freed ourselves from reference to prototype standards. Nevertheless, for practical dissemination it is not only economical but also more accurate to use a set of reference standards which are periodically remeasured in terms of the original defining experiment.

Thus, in the traditional areas—mass, length, volt, etc.—stable reference groups are maintained at NBS and at other laboratories. But even if, for example, the other laboratories maintained their length standards by direct reference to a Krypton lamp or had their own freezing point cells for realizing IPTS-68, there would still be the question of stability of the reference lamps or temperature cells over a period of time.

As soon as the question of the adequacy of the dissemination process is raised, a *set* of questions must be asked:

- What are the variance components entering into the precision at both laboratories?
- What instrumental, procedural, or environmental factors influence the measurement?
- If a reference group is moved to NBS, will it survive the trip unchanged?
- If the measurement processes are different at two laboratories, what is the appropriate transfer mechanism?
- How does one check the stability of the reference group internally at each laboratory?
- What evidence is needed to show that the process is in control?
- What measurements for bounds to possible systematic errors should be made?

To discharge its responsibility of disseminating the base units, the Bureau has introduced the concept of a Measurement Assurance Program (MAP). MAP looks at the whole system and determines its properties so that we can answer questions about the NBS process, the transfer operation, and the user's process.

These programs are designed to give a continuing evaluation of the performance of the participant's measurement process—for example, of his output when he uses the reference standard to calibrate other standards. The end result is documented evaluation of the adequacy of the measurement effort, and exact knowledge of the properties of NBS's processes for maintenance and dissemination in a form usable by the participant to assure the adequacy of his measurements. To date, service of this type is available in mass and volt. Other areas where similar programs are being developed are: resistance and capacitance, in which we are conducting preliminary tests with NASA, Sandia, Newark, and Redstone; RF power, with tests at Autonetics and, soon, four other laboratories; laser power, in tests for the Army; and cryogenic flow, with a test now in progress. Other areas, not as far along, are length, temperature and RF attenuation, voltage and impedance.

FROM STANDARDS TO PRACTICAL MEASUREMENT

The transfer from standard to practical measurement is a problem faced by all measurement laboratories. To illustrate the dimensions of this problem, let's look at temperature. New sensors are being introduced that are of a different type than that by which IPTS-68 is disseminated. A particular feature of these new, miniaturized temperature sensors is digital readout for automation purposes, with typical requirements that the equipment be small and highly sensitive, exhibit rapid response times, and be capable of producing electrical signals that can be easily digitized in order to interface with data processing systems.

We propose to react to the need posed by this rapidly changing measurement technology through a program that will: (1) evaluate and characterize modern temperature sensors with regard to reproducibilities, interchangeability, aging, time response, etc.; (2) interact with appropriate technical societies, manufacturers, researchers, etc., in order that the realization of temperature in the various fields of application may be strengthened and improved; and (3), as appropriate, disseminate information and techniques through publication and consultations.

Specifically, NBS has already been approached by a committee on instrumentation for the National Committee for Clinical Laboratory Standards, which has enumerated thermometry needs and asked for guidance and recommended methods to make accurate temperature measurements in the clinical laboratory. Particular concerns include sensors in instruments for enzyme-rate analysis, where accuracy, response time, and the size of the temperature sensor are paramount, and in pH and blood gas analysis, where temperature measurements require small sensors. A standard platinum resistance thermometer employed in realizing IPTS-68 has dimensions, fragility, time-constant, and associated instrumentation which render it entirely inadequate for most medical temperature measurements. A typical industrial platinum resistance thermometer (linear dimensions a few mm) or a thermistor of 0.5 mm diameter are small and rugged, and may well have the necessary characteristics to be directly applicable to medical thermometry. We need to start characterizing such sensors.

We anticipate that the eventual commercial production of instruments for similar work will make detailed information on the stability, time-response, and sensitivity of the incorporated temperature sensors mandatory. This will provide a great deal of needed background information. But the medical needs which are currently impinging upon

us are varied and, taken together, represent an increased awareness in the medical community of the importance of temperature in both routine and innovative applications, whether in the hospital ward or laboratory.

To provide interlaboratory compatibility, one will have to devise a program that looks at the output of the clinical laboratories to determine how the desired precision and compatibility can be achieved—a Measurement Assurance Program, if you will, which, because human lives may ultimately be at stake, should be a rigorous one indeed, although its precise form should be decided by the clinical laboratory.

DEMONSTRATING THE ADEQUACY OF MEASUREMENT

Adequacy of measurement can only be judged in the light of the end use. In pure calibration situations, such as those involving mass or voltage standards, the output consists of calibrations of other standards. The procedures and equipment are nearly the same everywhere. It is an easy matter to devise intercomparison schemes that provide a continuing check on the calibration output.

On the other hand, consider the case of radiopharmaceuticals. The goal here is that each and every patient receive, within some reasonable tolerance, the prescribed dose. NBS is cooperating with a medical group in a study in which "patients" treated by the doctors are sent to NBS to measure the actual dose given for comparison with the stated dose. In this case, the "patient" is a vial of liquid with a rubber stopper that permits the doctor to inject the radionuclide in nearly the same manner as he would into an actual patient. Note that this tests the output of the whole system. If troubles are discovered, one can check to see what elements in the total process are the source of trouble:

- —the method of preparation or dilution
- —error in dose calibrators
- —error in reference standards
- —error in value given by supplier.

The point is that one has to focus on the ultimate performance of the system, not just one of its components. It is the trustworthiness of the measurements, not just the behavior of an instrument, that is important to a standards laboratory.

This approach and these concepts are involved in the NBS Measurement Assurance Program for the basic physical quantities although the conditions of measurement are more restrictive. The end result is the same in both cases: scientific assurance that measurements are adequate to the need.

The role of measurement is being propelled into a position of prominence today. Let me illustrate in terms of references to NBS in legislation pending before the Congress. From the time that I arrived at NBS, fresh from graduate school in 1948, until the mid-60's, NBS received no new authorities as a result of legislative action. Since 1967, NBS has either actually been cited in a half dozen or more enacted bills or mentioned in their legislative history with the clear intent that NBS measurement capability should be applied to the subject problem of the legislation. Consumer Product Safety legislation and Noise Control legislation, which is expected to be enacted in this session of Congress, specifically designate a role for the Bureau.

But the reference to NBS is really only symbolic. The Congress is really calling on this country's total measurement capability to rise to the challenges posed by an increasingly complex and troubled society. NBS can't do it alone. We need your help as you need ours. Together, I think, we can do the job the country needs to have done.

Gypsum Industry Sponsors Research Associate

James L. Houser has joined the Bureau as a Research Associate to work on a program sponsored by the Gypsum Association.

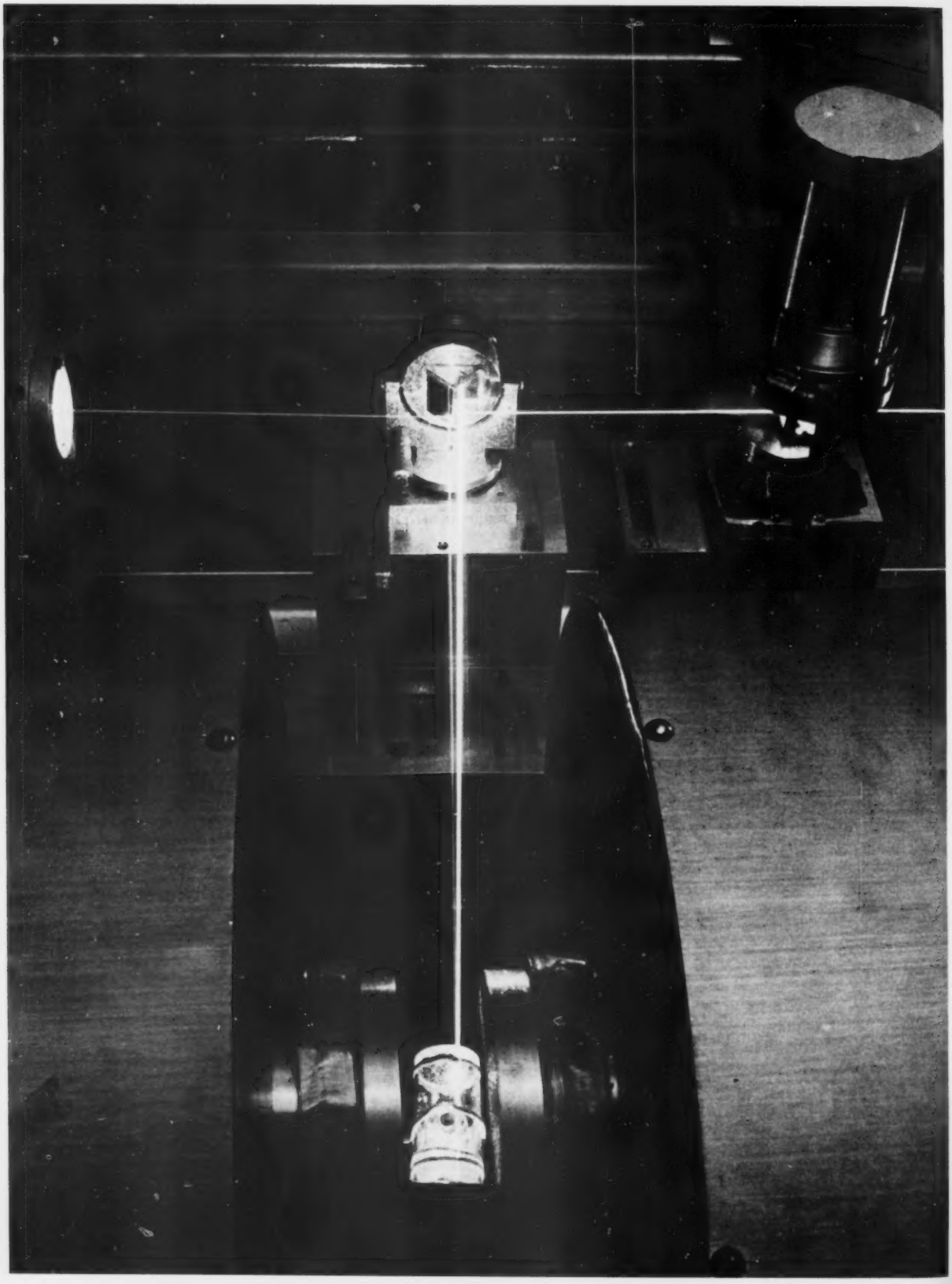
Houser's work at the Bureau will include investigations on the combustibility of building materials, testing methods, definitions, data analysis, new test methods, and criteria—all leading to a practical understanding and definition of noncombustibility for use in specifying the performance of building materials and systems.

In making the announcement of Houser's appointment, A. Victor Abnee, Jr., Executive Vice President of the Association, said:

"It is becoming increasingly important for the gypsum industry to retain close liaison with the Bureau concerning all aspects of fire technology."

The NBS Research Associate Program makes it possible for scientists and engineers from industrial corporations, professional organizations, and trade associations to work for specified periods on a full-time basis at the National Bureau of Standards on projects of clear mutual interest and prospective benefit to the technical community and the public. For detailed information concerning this program, contact:

Mr. P. R. de Bruyn
Industrial Liaison Officer
Admin. A402
National Bureau of Standards
Washington, D.C. 20234
Telephone (310) 921-3591.



MONITOR DEVELOPED FOR NITRIC OXIDE POLLUTION

Scientists at the Bureau have devised a new and improved method for monitoring nitric oxide in such source emissions as auto exhausts and electrical power plant stacks.[1] The procedure is simpler and more economical than existing methods of monitoring NO emissions and is not subject to interference from other contaminants in the sample. By extrapolation, sensitivity of 3 parts per million is achieved and further refinements are possible.

Nitric oxide is a major air pollutant and is the precursor to nitrogen dioxide, the trigger molecule in photochemical smog formation. When high levels of this pollutant are present, eye irritation and other discomforts are severe.

A prototype monitor, developed by A. Kaldor, W. B. Olson, and A. G. Maki of the Optical Physics Division, is based on the Zeeman shift of an NO absorption line into coincidence with a CO laser line. A static magnetic field, supplied by an electromagnet (or an appropriate permanent magnet) of 750 gauss (1 gauss = 10^{-4} tesla), Zeeman shifts the NO absorption line into near coincidence with the laser line. A small coil driven by an audio amplifier then generates a modulating magnetic field, sweeping the absorption line through the laser line, eliminating the need for a tunable laser. An infrared detector gives an output signal which is proportional to the amount of NO in the sample.

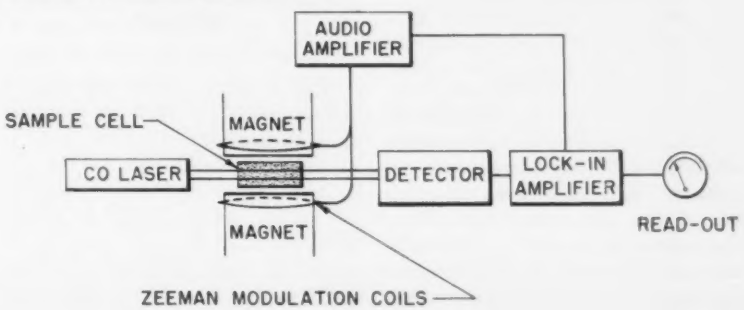
Measurement with the apparatus on laboratory samples of known NO content indicate that quantities as small as 60 ppm of NO are detectable with a signal-to-noise ratio of 70. Improvements in the detector and in laser stability can increase the sensitivity by a factor of 10 or more, and by using a multiple reflection absorption cell the absorption path can be increased by at least an order of magnitude. With these improvements the device should be able to measure quantitatively NO concentrations to better than 0.1 ppm. Also with an intracavity configuration the sensitivity of the device may be extended all the way to the parts per billion range.

The field is modulated with a frequency of 1 kHz; the amplitude of modulation was varied from about 10 to 100 gauss. Measurements were made in the pressure range from 1 to 30 torr (1 torr = 1.33 $\times 10^2$ Pa).

To optimize the sensitivity of the device for a small fixed amplitude of modulation, the NO transition having the largest product of intensity times the Zeeman shift coefficient was examined. Only the low J transitions of the $^2\Pi_{3\times2}$ state of NO show large Zeeman shifts. Of these only the $J = 5/2 \leftarrow 3/2$, $v = 1 \leftarrow 0$ transition at about 1884.32 cm^{-1} lies close to the CO laser line at 1884.37 cm^{-1}. In a magnetic field the $J = 5/2 \leftarrow 3/2$ transition splits into 12 electric dipole allowed transitions symmetrically displaced from the zero field transition. Four of these are $\Delta M = 0$ transitions absorbing light polarized parallel to the magnetic field (required for this experimental configuration). Calculations showed that the most sensitive transition to use for a small modulating magnetic field was the $M = -3/2 \leftarrow -3/2$ transition.

[1] Kaldor, A., Olson, W. B., and Maki, A. G., Pollution monitor for nitric oxide: A laser device based on the Zeeman modulation of absorption, Science **176**, No. 4034, 508 (May 5, 1972).

Block diagram of the monitor for nitric oxide pollution. By Zeeman shifting the NO absorption line into coincidence with the CO laser line, the device can detect NO pollution in several parts per million quantities.



Main components of the nitric oxide pollution monitor. A laser (left) is being used here as the source. The sample holder (bottom) is inside an electromagnet. Other components are a beam splitter (upper center) and the detector (upper right).

NSRDS NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

SECOND ISSUE OF JOURNAL OF PHYSICAL AND CHEMICAL REFERENCE DATA PUBLISHED

Volume 1, No. 2 of the new quarterly *Journal of Physical and Chemical Reference Data* has been published by the American Chemical Society and the American Institute of Physics for the Bureau. The *Journal* publishes the major output of the National Standard Reference Data System. Abstracts of the critical compilations and reviews included in the second issue are:

SELECTED VALUES OF HEATS OF COMBUSTION AND HEATS OF FORMATION OF ORGANIC COMPOUNDS CONTAINING THE ELEMENTS C, H, N, O, P, AND S

Eugene S. Domalski

Selected values of the heats of combustion and heats of formation of 719 organic compounds are reported here. The data tabulated pertain to compounds containing the elements carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur (CHNOPS). The information is arranged according to classes of compounds and within each class, compounds are arranged by empirical formula. The general classes covered are: hydrocarbons, alcohols, phenols, polyols, ethers, aldehydes, ketones, acids, acid anhydrides, esters, steroids, lactones, carbohydrates, heterocyclic oxygen compounds, amines, amides, urea derivatives, guanidine derivatives, amino acids, peptides, alkaloids, heterocyclic nitrogen compounds, porphyrins, organic sulfur compounds, and organic phosphorus compounds. When a selection was made from among several investigators, commentary is provided to indicate the choice, and usually some relevant data. The number of references cited is 596. An alphabetical compound index is provided which gives the name, page number, empirical formula, and the Wiswesser Line Notation (WLN), for each compound.

THERMAL CONDUCTIVITY OF THE ELEMENTS

C. Y. Ho, R. W. Powell, and P. E. Liley

This is the abridged version of a comprehensive volume on the thermal conductivity of the elements. It contains recommended reference values resulting from critical evaluation, analysis, and synthesis of all the available data. It also gives estimated values for those elements for which no thermal conductivity data are available. Thus, the work provides recommended or estimated thermal conductivity values for all the elements over the full temperature ranges where experimental data are available or reliable extrapolations or estimations can be made. The results on each element are presented in both graphical and tabular forms. Summary graphs arranged by group in the periodic table are also given.

THE SPECTRUM OF MOLECULAR OXYGEN

Paul H. Krupenie

This is a critical review and compilation of the observed and predicted spectroscopic data on O_2 and its ions O_2^-, O_2^+, and O_2^{2+}. The ultraviolet, visible, infrared, Raman, microwave, and electron paramagnetic resonance spectra are included. Each electronic band system is discussed in detail, and tables of band origins and heads are given. The microwave and EPR data are also tabulated. Special subjects such as the dissociation energy of O_2, perturbations, and predissociations are discussed. Potential energy curves are given, as well as *f*-values, Franck-Condon integrals, and other intensity factors. A summary table lists the molecular constants for all known electronic states of O_2 and O_2^+. Electronic structure and theoretical calculations are also discussed.

A CRITICAL REVIEW OF THE GAS-PHASE REACTION KINETICS OF THE HYDROXYL RADICAL

William E. Wilson, Jr.

The literature pertinent to reactions of the hydroxyl radical has been reviewed. An extensive discussion is given for reactions of the hydroxyl radical with itself and with CO, H_2, and CH_4. These four reactions are:

$$OH+OH \rightarrow H_2O+O; \quad (1)$$
$$CO+OH \rightarrow CO_2+H; \quad (2)$$
$$H_2+OH \rightarrow H_2O+H; \quad (3)$$
$$CH_4+OH \rightarrow CH_3+H_2O. \quad (4)$$

Values are recommended for k_1 and k_2 and for the ratio k_3/k_2 and k_4/k_2. These rate ratios are used with the previously established value of k_2 to obtain recommended values for k_3 and k_4.

The recommended values in $cm^3\ mol^{-1} \cdot s^{-1}$, the temperature range, and the uncertainty are:

$k_1 = 1.55 \times 10^{12}$, 300 K, $\log k \pm .5$
$k_2 = 3.1 \times 10^{11} \exp(-300/T)$, 300–2000 K, $\log k \pm .3$
$k_3/k_2 = 73 \exp(2300/T)$, 300–2000 K, $\log k_3/k_2 \pm .3$
$k_3 = 3.8 \times 10^{13} \exp(-2600/T)$, 300–2000 K, $\log k \pm .3$
$k_4/k_2 = 92 \exp(2200/T)$, 300–2000 K, $\log k_3/k_2 \pm .3$
$k_4 = 2.85 \times 10^{13} \exp(-2500/T)$, 300–2000 K, $\log k \pm .7$.

Rate expressions are also recommended for a number of other hydroxyl reactions whose rates are less well established.

REPRINTS

Bound reprint copies of each of the articles appearing in the second issue are available for purchase from the American Chemical Society, 1155 16th Street, NW., Washington, D.C. 20036.

1. *Selected Values of Heats of Combustion and Heats of Formation of Organic Compounds Containing the Elements C, H, N, O, P, and S* by Eugene S. Domalski, 57 pp, $4.50.

2. *Thermal Conductivity of the Elements* by C. Y. Ho, R. W. Powell, and P. E. Liley, 144 pp, $7.

3. *The Spectrum of Molecular Oxygen* by P. Krupenie, 112 pp, $6.

4. *A Critical Review of the Gas-Phase Reaction Kinetics of the Hydroxyl Radical* by W. E. Wilson, Jr., 39 pp, $4.

Single copies of the *Journal of Physical and Chemical Reference Data* are also available from the American Chemical Society for $16. Make all checks payable to the American Chemical Society.

SUBSCRIPTION INFORMATION

Subscriptions to the *Journal of Physical and Chemical Reference Data* are available as follows: member,* domestic** $20, foreign $23; nonmember, domestic** $60, foreign $63. Subscriptions should be placed with the American Chemical Society at the above address.

RATE CONSTANTS OF GAS PHASE REACTIONS

Rate Constants of Gas Phase Reactions Reference Book by V. N. Kondratiev has been translated from the Russian by L. J. Holtschlag and edited by R. M. Fristrom, both of the Applied Physics Laboratory, Johns Hopkins University. The Office of Standard Reference Data has published and made the book available for purchase from the National Technical Information Service, Springfield, Va. 22151 for $8.50. The translation should be ordered under the number COM-72-10014. This reference book is a survey of the kinetics of bimolecular and termolecular reactions covering the world literature to the end of 1969. Gas-phase reactions of neutral particles, including atoms, radicals, and electronically excited molecules, are examined and tables of rate constants presented in consistent units. A number of reactions in the book have been critically evaluated. The translators have added a table of equilibrium constants as well as a bibliography of rate constant compilations and sources of evaluated kinetic information.

*Member of ACS, AIP, or an affiliated society.

**Domestic rates apply to United States and possessions, Canada, and Mexico.

PROPERTIES OF SELECTED SUPERCONDUCTIVE MATERIALS

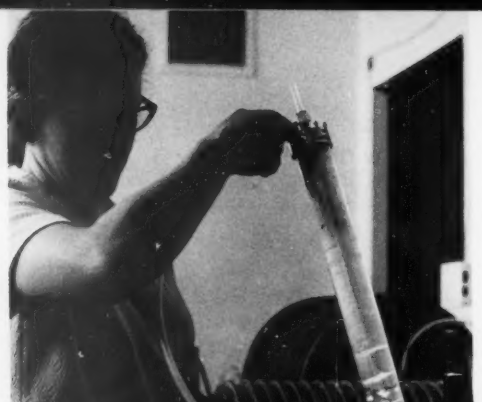
NBS Technical Note 724, *Properties of Selected Superconductive Materials* by B. W. Roberts,[1] General Electric Research and Development Center, Schenectady, N.Y. ($1, SD Catalog No. C13.46:724), is a noncritical compilation of data on superconductive materials that has been extracted from a portion of the literature published up to early 1971. This publication extends the data previously published in NBS Technical Note 482, May 1969. The properties compiled are composition, critical temperature, critical magnetic field, crystallographic data, and lowest temperature tested for superconductivity.

The compilation consists of three major tables. Table 1 lists the elements and some of their superconductive properties. The data have been selected generally from recent studies whose authors appear to have given serious consideration to sample purity and perfection. Table 2 contains reported data on superconductive materials plus all materials that have been tested specifically for superconductivity down to some temperature T_n without discovery of a transition. Because superconductive properties vary with purity and other metallurgical aspects, the author has recommended that the appropriate literature be checked to determine the most probable critical temperature or critical field of a given alloy. Table 3 presents data on those materials exhibiting superconductivity in a high magnetic field.

Technical Note 724 also includes review articles concerned primarily with the experimental and material aspects of superconductivity, a bibliography, and a complete

Continued on page 227

IMPROVED THERMOCOUPLE TABLES FOR Pt10Rh/Pt AND Pt13Rh/Pt THERMOCOUPLES



Margaret Scroger extracts a gold freezing-point cell from the furnace after calibration of Pt-Rh thermocouples.

New reference tables for platinum 10 percent rhodium/platinum and platinum 13 percent rhodium/platinum thermocouples have been prepared through a cooperative program among NBS, the National Physical Laboratory (United Kingdom), and the National Research Council (Canada).[1]

Existing tables in the United States and United Kingdom were not in agreement due to different realizations of temperature scales in the original calibrations and compositions of the platinum and rhodium/platinum wires.[2,3] In addition, since the original tables were derived, substantial improvements in the purity of both platinum and rhodium have been attained. This created the situation in which intentional compositional changes of the alloy arms from the nominal values were necessary in order for the thermocouple emf-temperature relationships to comply with the tables. As a result substantial differences developed between thermocouples that were made to meet United States and British specifications. Thus, upon adoption* the new tables will permit manufacturers with an international market to meet the specifications of a single set of table values. The new tables also take into account the changes incorporated in the 1968 IPTS scale.

*The tables are in the process of adoption by ASTM and the British Standards Institute.

The new tables are based on calibrations of thirty-two Pt10Rh/Pt and thirty-six Pt13Rh/Pt thermocouples that were constructed from material supplied by seven manufacturers from the United States and the United Kingdom. The alloys used for these thermocouples are as close to the nominal values of Pt10Rh and Pt13Rh as was possible to obtain. By comparison, existing thermocouples (produced in this country prior to 1972) use alloys that contain slightly less than 10 or 13 percent rhodium by weight and therefore their emf-temperature relationships do not comply closely with those given by the new tables. The emf-temperature values of existing thermocouples are typically lower than the values given by the new tables by about 0.25 to 0.5 percent within the 400 to 1400 °C range.

NBS and NRC calibrated the thermocouples over the temperature range from −50 to 1064.43 °C by comparisons with platinum resistance thermometers over the lower parts of the range (up to 500 °C), and at the freezing points of tin, zinc, antimony, silver, and gold. The NPL made calibrations from the gold point (1064.43 °C) upwards by comparisons with a photoelectric pyrometer that was calibrated according to the IPTS-68. After the completion of these measurements, thermocouple intercomparisons over the whole temperature range were performed at NBS and NRC.

Prior to the calibrations all thermocouple wires were annealed electrically at 1450 °C for 30 minutes and slowly cooled to room temperature. Thermocouples were then constructed from the wire and mounted in sintered recrystallized alumina twin-bore tubing.

NBS CALIBRATIONS

At NBS thirteen Pt10Rh/Pt thermocouples and five Pt13Rh/Pt thermocouples were calibrated by intercomparison with a standard platinum resistance thermometer (PRT) in stirred liquid baths at 50 °C intervals from 50 to 500 °C, and at 232.0 and 419.6 °C (near the

freezing points of tin and zinc, respectively). Five of each type were also calibrated by intercomparison with the standard PRT in a cryostat at −50 °C. All 18 of the thermocouples were calibrated twice in the stirred liquid baths; in the first instance the calibration points were determined with increasing bath temperature between the temperature measurement points and in the second instance, with decreasing bath temperature. The 18 thermocouples were then calibrated in freezing point cells at the tin, zinc, antimony, silver, and gold points. Additionally, one Pt10Rh/Pt and eight Pt13Rh/Pt thermocouples were calibrated at these fixed points.

The emfs of the thermocouples were measured with a calibrated six-dial potentiometer that had a resolution of 0.01 μV and the error did not exceed the limit ±(0.002 percent of voltage measured ±0.1 μV). All platinum thermometer resistances were measured with a G-2 Mueller bridge.

Eight of the Pt10Rh/Pt thermocouples that were calibrated by intercomparison with the PRT and at the fixed points were selected to serve as reference thermocouples. The other eight Pt10Rh/Pt and all eighteen Pt13Rh/Pt thermocouples were intercompared with these references. The intercomparisons were performed in a horizontal metal-tube furnace at 100 °C intervals from 1100 °C to 500 °C, at 300 °C, at 100 °C, and at the five fixed points.

NRC CALIBRATIONS

Sixteen Pt10Rh/Pt and nine Pt13Rh/Pt thermocouples were calibrated at the National Research Council; these thermocouples had been fabricated, but not calibrated, at NBS. These calibrations were performed in a fixed-point furnace at the freezing points of tin, zinc, antimony, silver, and gold in that order. Seven of the thermocouples were also calibrated at the freezing point of copper. The same 25 thermocouples were then calibrated, nine at a time, in stirred water and stirred oil baths by intercomparison with a platinum resistance thermometer at small temperature intervals from 0 °C to 50 °C, at 25 °C intervals from 50 °C to 350 °C, and at 231.9 °C.

Each thermocouple was calibrated at least twice at both increasing and decreasing temperatures sequences. All thermocouples were then intercompared over the temperature range from 20 to 1100 °C with both increasing and decreasing temperature sequences. For the most part, the measurements were reproducible within 1 μV.

NPL CALIBRATIONS

Four Pt10Rh/Pt and four Pt13Rh/Pt thermocouples, which were fabricated from the material that was supplied by each of two manufacturers, were sent to NPL; half of the thermocouples had been calibrated at NBS and the other half at NRC. The 16 thermocouples were calibrated at NPL in a platinum blackbody enclosure whose temperature was measured with a photoelectric pyrometer. Calibrations were performed at 1064, 1158, 1244, 1326, 1443, 1528, and 1605 °C. Additional measurements were made by comparison with the photoelectric pyrometer up to the platinum point, and for this purpose it was necessary to replace the platinum blackbody with a more refractory one that was constructed of alumina.

One of the conclusions drawn from this work was that the value of temperature found for the freezing point of platinum (approximately 1768 °C) was about 4 degrees lower that the value recommended in the supplementary information given in the text of the IPTS-68.

REFERENCE TABLES

The reference tables were derived from polynomials which relate emf as a function of t_{68} fitted, by means of least-squares orthogonal polynomial techniques, to a selected group of thermocouples of each type.

For the Pt10Rh/Pt thermocouples, a second degree polynomial was fitted to the mean emfs at 630.74 °C, 961.93 °C, and 1064.43 °C from the NBS and NRC calibrations on the selected thermocouples. Polynomials were then fitted to all of the available data below 630.74 °C, the polynomials being constrained to give an emf of 0 μV at 0 °C and the same emf as the above quadratic at 630.74 °C. A 6th degree equation that yielded a standard deviation for the residuals, between the observed and computed points, of 0.53 μV (70 points) was the best choice. A similar fitting was used for the Pt13Rh/Pt thermocouples.

If a single polynomial was used to represent the entire temperature region from 1064.43 °C to 1767.6 °C, it would necessarily be of high degree to accommodate the rapid decrease of dE/dt_{68} above 1700 °C. It was desirable, therefore, to divide this region into two parts (1064.43 °C to 1665 °C, and 1665 °C to 1767.6 °C) for fitting polynomials. A 3d degree polynomial was found to be sufficient for representing these data.

Copies of the tables or additional information may be obtained by writing to:

G. W. Burns or M. G. Scroger
B228 Physics Building
National Bureau of Standards
Washington, D.C. 20234

[1] Bedford, R. E., Ma, C. K., Barber, C. R., Quinn, T. J., Chandler, T. R., Burns, G. W., and Scroger, M., New reference tables for platinum 10 percent rhodium/platinum and platinum 13 percent rhodium/platinum thermocouples, Proc. 5th Temperature Symposium—**[Temperature, Its Measurement and Control in Science and Industry]**, held in Washington, D.C., June 1971, to be published by ISA, Philadelphia, Pa.

[2] Shenker, H., Lauritzen, J. I., Jr., Corruccini, R. J., and Lonberger, S. T., Reference Tables for Thermocouples, Nat. Bur. Stand. (U.S.), Circular 561, (Apr. 1955).

[3] Reference Tables for Platinum/Rhodium vs. Platinum Thermocouples, British Standards Institution B.S. 1826: 1952, London, W.1. (Sept. 1952).

IMPROVED VERSION OF OMNITAB COMPUTING SYSTEM RELEASED

The Bureau has issued OMNITAB II, the current version of its general-purpose OMNITAB computing system, for the first time making it available to the public. The new system, consisting of a magnetic tape containing the program plus complete documentation in four publications, is available for $250.[1]

OMNITAB II is a highly user-oriented system for a large computer, designed to make computing easy, accurate, and effective, particularly for those who are not programmers. It is a general-purpose, easily learned system for simple or complex numerical and statistical data analysis. Problem solving is achieved by instructions that take the form of simple English sentences and by the natural structure of the system and its many features. OMNITAB II is a virtually machine-independent computer system which has been used successfully in government, industry, and universities across the country and in several centers abroad. It has been implemented with relative ease on large computers from at least seven different manufacturers.

Experience over the years in the use of OMNITAB has proved it to be a highly efficient means of problem solving in a remarkably wide range of applications. Efficiency of the system arises from two main attributes—the simple English vocabulary of over 250 words which permit operations to be performed on columns or arrays of numbers and a large number of operators that invoke a complex sequence of operations requiring dozens of lines of code in other programming languages.

The 2,400-foot reel of tape contains: (1) the main program and subprograms, (2) test problems—sets of OMNITAB instructions that serve as bench marks when implementing the system, (3) FORTRAN comment statements that also serve as a guide in implementation, and (4) the output obtained by running the test problems on the NBS computer. Three of the publications[2] (SP339, TN550, and TN551) consist largely of copies of essential portions of the tape. In addition, TN550 points out, for the systems programmer, where difficulties may occur and how to cope with them; TN551 includes instructive illustrations of the many ways to print results. The remaining publication, TN552, is the basic source of information on how to use the system.

Part A, the first of the four parts of TN552, general reference manual, gives a simple, compact introduction to OMNITAB II for people who have had no experience using a large computer or OMNITAB. Part B describes the general features of the OMNITAB II computing system. Part C provides detailed explanations, with examples, of the use of specific instructions. Part D is a complete alphabetical list of all the instructions in the system. In addition to a comprehensive table of contents at the beginning of the manual, there is, at the beginning of Part C, a list of commands under functional titles, and at its end, an index to these commands.

OMNITAB was developed originally in the Heat Division in 1963 under the guidance of Joseph Hilsenrath who served as principal architect, patron, and salesman. In 1966, a change of computer dictated a major rewriting effort which was undertaken by Walter J. Gilbert of the Computer Services Division who made substantive changes and improvements in the internal structure of OMNITAB.

Since 1968, the responsibility for the development and documentation of OMNITAB has been under the supervision of David Hogben of the Statistical Engineering Laboratory, Applied Mathematics Division. Version 5 of OMNITAB II, which has just been released to the general public, has been programmed largely by Sally T. Peavy and Ruth N. Varner. Mrs. Peavy is responsible for the maintenance of the system. Other contributors of subroutines to the system include: William G. Hall, David Hogben, Robert C. McClenon, Carla G. Messina, Bradley A. Peavy, M. Stuart Scott, Irene A. Stegun, Philip J.

A REMINDER

NBS is holding a Conference on Dimensional Accuracy in Manufacturing at Gaithersburg, Md., Oct. 30–Nov. 1, 1972. Recent advances in machine tools, numerical control, gages, precision parts, lasers, and computers will be discussed. For more information, contact A. G. Strang, B164 Physics, National Bureau of Standards, Washington, D.C. 20234.

Walsh, Roy H. Wampler, and Ruth Zucker.

Early interest in OMNITAB by a number of universities abroad has stimulated the development of vocabularies and associated phrases for OMNITAB in languages other than English. OMNITAB II vocabularies now exist in Dutch, Italian, Danish, and Slovene.

[1] **OMNITAB II** Magnetic Tape and Documentation Parcel by David Hogben, Sally T. Peavy, and Ruth N. Varner, consisting of one reel of magnetic tape, issued October 1970, and four documentation items, issued November 1970 to October 1971, price $250. Order parcel (tape and four documents listed above) from: National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

[2] The documentation items are available separately from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 or local U.S. Department of Commerce Field Offices at the prices indicated below: Source Listing of OMNITAB II Program, NBS Spec. Publ. 339, issued December 1970, 371 pages, $4.75; SD Catalog No. C13.10:339. A Systems Programmer's Guide for Implementing OMNITAB II, NBS Tech. Note 550, issued November 1970, 42 pages, 50 cents; SD Catalog No. C13.46:550. Test Problems and Results for OMNITAB II, NBS Tech. Note 551, $1.50; SD Catalog No. C13.46:551. OMNITAB II User's Reference Manual, NBS Tech. Note 552, issued October 1971, 264 pages, $2; Stock No. 0303-0918.

Sample OMNITAB II instructions are given in each of ten categories.

Printing Data
PRINT columns 1, 2, and 5

Arithmetic Operation
MULTIPLY column 1 by 7.6 and put the results in column 2

Data Manipulation
PROMOTE by 5 rows column 12 into column 14

Statistical Analysis
FREQUENCY distribution of column 31 put in column 32

Numerical Analysis
INTERPOLATE X in 2, Y in 1, length 10, 5 values in 3, 3 pts, put in 5

Repeat Mode
PERFORM instructions 2 thru 7, 20 times

Array Operation
ADIVIDE array in 1, 11 size 5 x 4 by 2.3, put in 11, 21

Matrix Operation
MINVERT matrix in 11, 21 size 4 x 4, put inverse in 1, 11

Bessel Function
BJZERO of column 41 put in column 42

Thermodynamics
ATOMIC mass table put in column 11

Sample Manipulative Instructions.

EXCHANGE column 1 with column 2, and col 3 with col 4

ERASE columns 7, 8, and 11

DEFINE 6.7 into row 3 of col 5

FLIP column 10 into column 11

CENSOR col 2 for 0.0, replace by 1.0, put in col 3

SEPARATE from col 1 every 2nd row, start row 3, put in col 2

MATCH column 22 with 3.0, extract from col 21, put in col 31

SORT column 1, carry along columns 11, 12, and 13

SHORTEN col 11 for col 12 = 5.3, put shortened cols in 21 and 22

NSRDS NEWS *Continued*

alphabetical cross index to authors by reference number.

BIBLIOGRAPHY ON ATOMIC ENERGY LEVELS AND SPECTRA

NBS Special Publication 363, *Bibliography on Atomic Spectra Energy Levels and Spectra, July 1968 through June 1971*, by Lucy Hagan and W. C. Martin[1] ($1, SD Catalog No. C13.10:363) is the first of a series of bibliographies expected to be issued under the same title by the Atomic Energy Levels Data Center. With the exception of a few references to earlier papers, the bibliography begins chronologically where C. E. Moore's Special Publication 306, Sections 1-4, *Bibliography on the Analyses of Optical Spectra* (Sec. 1, $1; Sec. 2, 60 cents; Sec. 3, 50 cents; Sec. 4, 55 cents; SD Catalog No. C13.10:306-1, 306-2, 306-3, and 306-4) left off. The present publication contains approximately 1,100 references classified by subject for individual atoms and atomic ions. A number index identifies the references. An author index is also included. References included contain data on energy levels, classified lines, wavelengths, Zeeman effect, Stark effect, hyperfine structure, isotope shift, ionization potentials, or theory which gives results for specific atoms or atomic ions.

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

BOLOVAC REASSESSED

In January 1972 the Bureau released an article entitled "Bolovac Eyes Industrial Market" which subsequently appeared in the February 1972 issue of the Technical News Bulletin. Further developments on the Bolovac have emphasized the importance of some unresolved questions.

These questions relate primarily to the routine fabrication of suitable disk-film-resistors. Although it may be possible to fabricate a Bolovac which would perform in the manner described in the reports, this has not been done to date. Further research into both the properties of thin films and suitable supporting structures will be needed before the Bolovac could be considered an economically attractive device.

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